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# Radio frequency receiver of long-term evolution system design by MATLAB Simulink

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**ABSTRACT**

For wireless broadband communication long-term evolution (LTE) is a standard for also mobile devices and data terminals, by using different radio interface together with core network improvements LTE increases the capacity and speed of mobile network. In this paper radio frequency receiver of radio-frequency long-term evolution (RF-LTE) is design and simulated using MATLAB Simulink, where the design based on illustrating parameters of each stage in LTE RF receiver from generating LTE waveform to error vector magnitude (EVM) measurements, where simulation results with 8 MHz bandwidth the transmitted signal power -3200 dBm, the received signal power (-140 to -160) dBm, while the demodulated signal reaches to -60 dBm difference between main loop and side loop witch lead to high confident recovered signal, also complementary cumulative distribution function (CCDF) measurements applied on output signals so that computes the power of complementary for cumulative distribution CCDF function from signal in time domain. Where CCDF curve shows value of time that a signal stand still above the level of average power for the measured signal or the probability of signal power will be above the level of average power.



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## 1. INTRODUCTION

Long-term evolution (LTE) is the fifth generation cellular networks air interface supporting where LTE is designed spatially for communications of packet data [1], [2], the technology emphasis is the high efficiency spectral density, data rates with high peak, flexibility of frequency and low latency [3]. The standards of LTE continue to cover multiple releases to satisfy the requirements that deal with data throughput improving, lower latencies, and flexible configurations increasing. After releasing are stopped, third generation partnership project (3GPP) resumes with new version of the standards to fixing errors, but with same old features that introduced [3]. The LTE 13 standard which is called LTE-Advanced Pro. Which developed for specific applications. LTE operation in both unlicensed and licensed spectrum. Aggregation of carrier with inter site, to be with the backhaul and capabilities of adjacent cells. Enhancing of communication in machine-to-machine.

Radio-frequency (RF) characteristics and minimum performance requirements can be described by technical specifications that contain many complex test cases [1]-[3]. While requirements of an RF transceiver with some of the specifications can be directly translated into, other specifications that require a detailed review. Long-term evolution radio-frequency (LTE-RF) will review a few important stages described [4], [5].

The LTE RF stages in [1] is analyzed and it will be shown that the stages is imposing very stringent parameters that makes each stage work probably. Blocking parameters will be reviewed in detail using MATLAB transmitter and Simulink signal frequency analyzer that will show the LTE reciver can be design and simulated using a built-in receiver wizard, which provides perfect design as in to [1], [6], [7]. The effect of phase locked loop noise on the error vector magnitude (EVM) of a LTE signal will be implemented and illustrated. In the design the phase noise impairments created and can be used to quickly evaluate the effect of different radio-frequency (RF) phase-locked loop (PLL) on the EVM performance of an LTE signal [8]-[10].

## 2. LTE RF DESIGN

The Figure 1 shows the main blocks of the preposed design. LTE waveform used to generated the input signal to the reciever [7]-[9]. Then filtered, transmitted using additive white gaussian noise (AWGN) as channel propagation before intering to the model of RF receiver that acheived with RF Blockset. Preposed model is based on standerd available stages. Then figures of EVM are taken from RF receiver block [10]-[12].

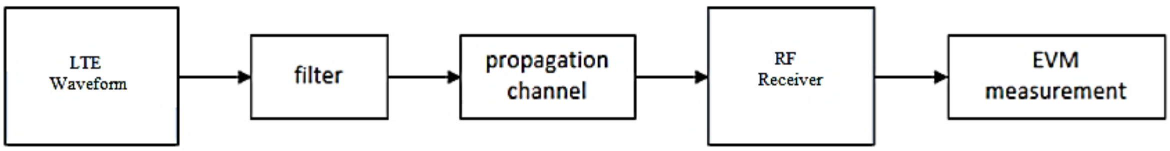
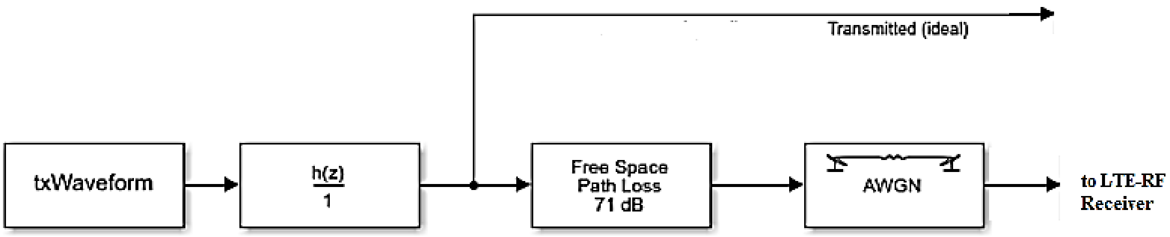



Figure 1. LTE-RF receiver block diagram

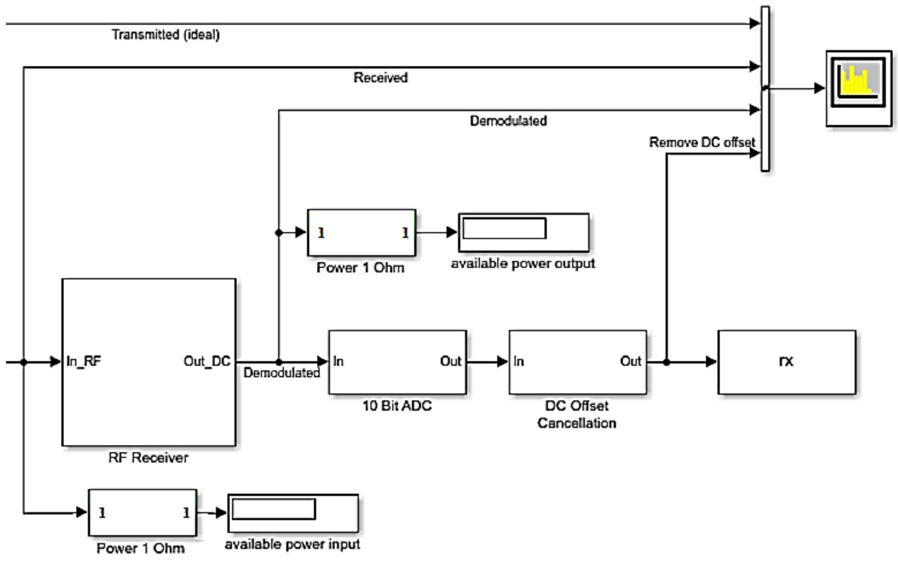
## 3. LTE RF RECIEVER MODEL

Acording Figure 1, LTE-RF transmitter and receiver design using MATLAB Simulink as shown in Figure 2(a) and Figure 2(b) respectivilly, this design consist of the fallowing blocks: Tx waveform, filter, free space loss, AWGN propagation channel, RF reciver, analog-to-digital converter (ADC), direct current (DC) offset, receiver (Rx), and the output signals taken from spectrum analyzer [1]. At TxWaveform reading data values in time series or matrix or structure format from workspace. Format with time series can be used with any data type, fixed dimensions or complexity, where transmitted wave implemented and processed in the LTE-RF reciver [1], [13], [14]. Descrit finite impulse response (FIR) filter none dependently filter of each channel for input over time using FIR filter. Specifing filter parameters using either separate input ports or parameters of tunable dialog, which are suitable for coefficients with time-varying, filter response used for band limitation of Tx waveform [1], [15]-[20].

Free space path loss the amplitude of the input signal can be reduced by the amount specified. Where loss directly by the decibels mode or indirectly by the distance and frequency mode as illustrated in Figure 3. This Bloch added free space path loss to filterd transmitted signal [21], [22]. AWGN channel adding white Gaussian noise to the input signal. This block supports multichannel processing as shown in Figure 4. When using either for variance modes with complex inputs. Information used: initial seed 67 and $E_s$/No units signal-to-noise ratio (SNR) dB. RF receiver, the RF receiver model includes the elements shown in Figure 5, where the RF demodulator consists of the following stages as shown in Figure 6 [1], [23], [24]. RF receiver, the RF receiver model includes the elements shown in Figure 5, where the RF demodulator consists of the following stages as shown in Figure 6 [1], [23], [24].




(a)




(b)

Figure 2. LTE-RF transmitter and receiver design using MATLAB Simulink: (a) LTE transmitter Simulink design and (b) LTE-RF MATLAB Simulink design

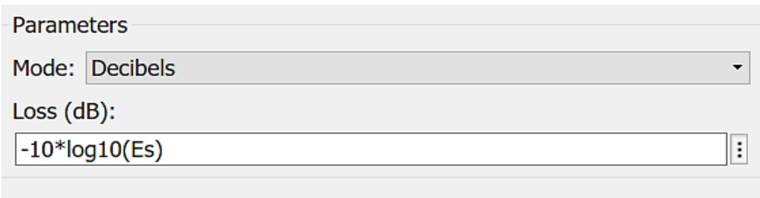



Figure 3. Free space path loss parameter

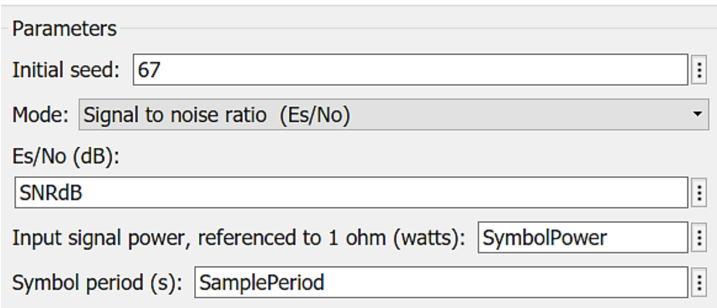



Figure 4. AWGN parameters

LTE direct conversion receiver, estimate the impact of non-linearity, noise, DC offset, mismatches and imbalance introduced by an RF chain composed by an low noise pre amplifier (LNA), direct conversion demodulator and variable gain amplifier (VGA) parameters illustrated in Table 1, internat protocol (IP3) which is a well-known specification that controlling linearity in radio frequency functions and stages, The output power versus input power behavior of both amplifiers shows that p - 12 dB of parallel amplifier is better than single path LNA [25]. 10-bit ADC estimate the impact of the quantization error and the saturation introduced by an ideal analog-to-digital converter as shown in Figure 7, introduce saturation and quantization on signals that complex, power with full Scale -30 dBm, normallization resistence 1, number of quantization levels 10. DC offset cancelation parameters of DC offset shown in Figure 8 which estimate the DC offset of a signal using a running average filter, and removes it from the signal itself, length of averging filter 32,

intial condition $5\times10^4$. At Rx block writing input to specified time series or structure in a workspace, where recived signal can be taken to be processed as output signal of LTE-reciever.

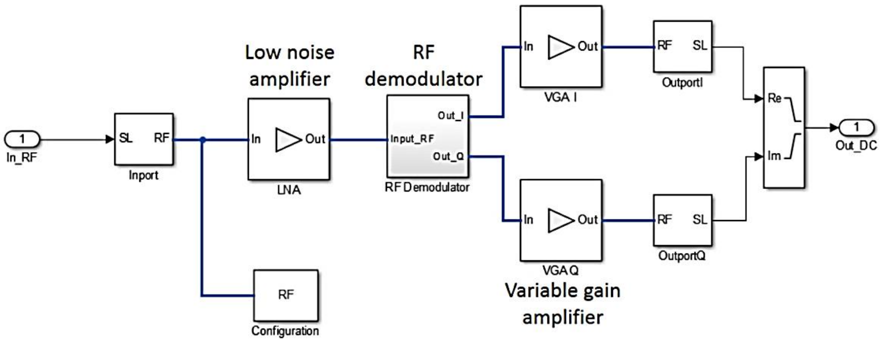



Figure 5. RF receiver Simulink design

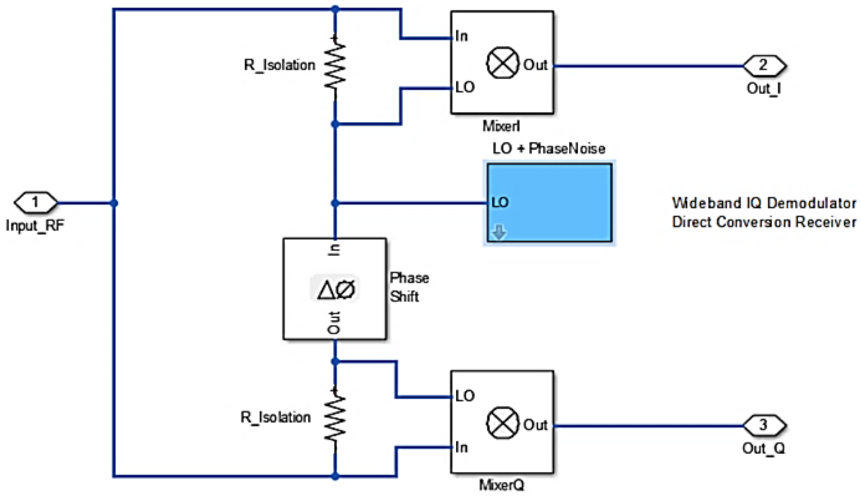



Figure 6. RF demodulator Simulink design

Table 1. Direct conversion demodulator parameters

| Simulation parameters | | Direct conversion demodulator characteristics at center frequency | |
|---|---|---|---|
| Center frequency | 2.14 GHz | Voltage conversion gain | 2.3 dB |
| LNA parameters | | I/Q gain mismatch (real and imaginary) | 0.05 dB |
| Gain | 17.4 dB | RF to LO Isolation (radio frequency to local oscillator) | -60 dB |
| Reverse isolation | -33 dB | IP2 | 56 dBm |
| Input return Loss | -33 dB | IP3 | 25.9 dBm |
| Noise figure | 1.2 dB | Noise figure | 10.9 dB |
| IP3 | -6.6 dBm | VGA characteristics at low frequency | |
| P1 | -12 dB | Linear gain | 20 dB |

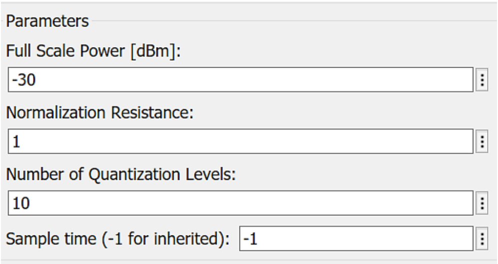



Figure 7. Analog-to-digital converter parameters

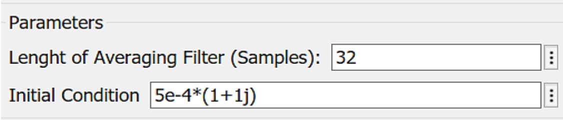
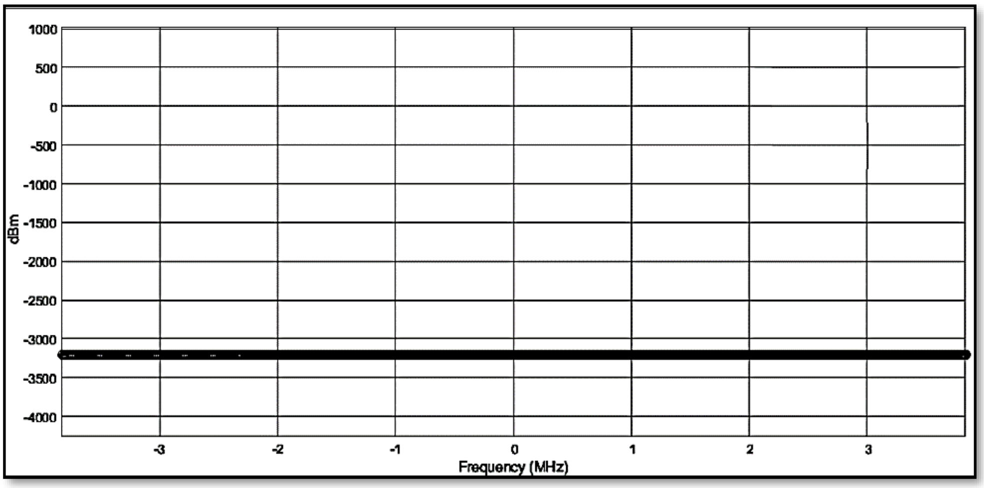


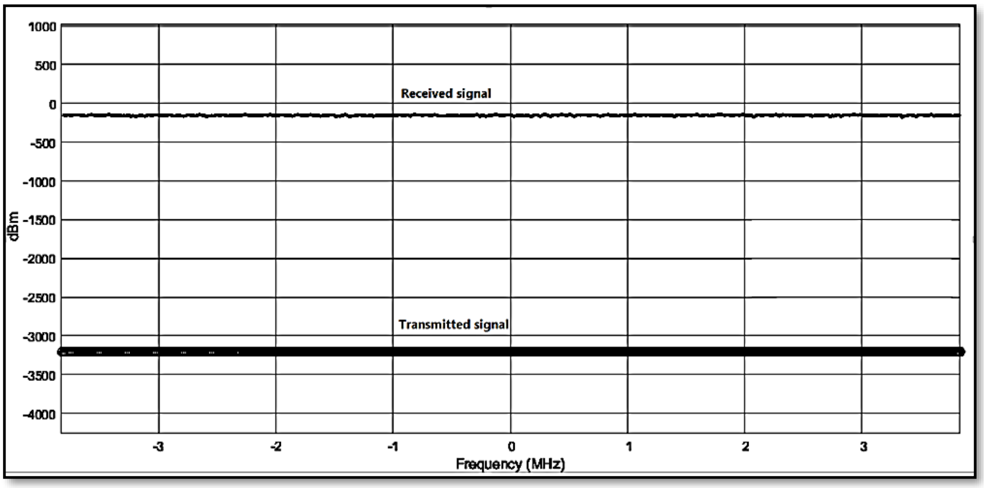

Figure 8. DC offset cancelation parameters

## 4. RESULTS AND DISCUSSION

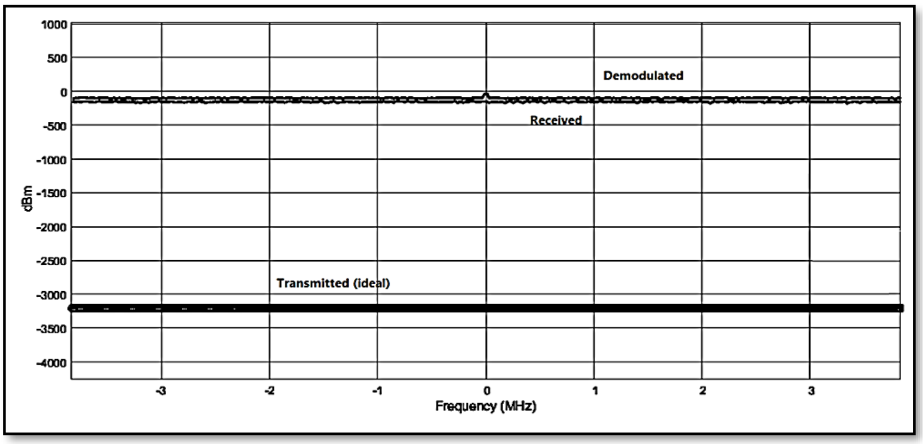
LTE-RF receiver design and simulated using MATLAB Simulink as in Figure 2, simulation results plotted from spectrum analyzer where transmitted, received, demodulated, removed DC offset signals illustrated in Figures 9(a), Figure 9(b), and Figure 9(c) respectively as shown belows. Simulation results with 8 MHz bandwidth the transmitted signal power -3200 dBm as shown in Figure 9(a), the received signal power (-140 to -160) dBm as shown in Figure 9(b), Figure 9(c) shows the merging between signals in prevous figures, while the demodulated signal reaches to -60 dBm difference between main loop and side loop witch lead to high confident recovered signal as shown in Figure 10, also complementary cumulative distribution function (CCDF) measurements applied on output signals that computes the power of complementary for cumulative distribution CCDF function from signal in time domain. Where CCDF curve shows as in Figure 11 the value of time that a signal stand still above the level of average power for the measured signal or the probability of signal power will be above the level of average power.




(a)




(b)




(c)

Figure 9. Simulation results plotted from spectrum analyzer where transmitted, received, demodulated, removed DC offset signals: (a) ideal transmitted signal, (b) ideal transmitted and received signals, and (c) ideal transmitted, received and demodulated signals

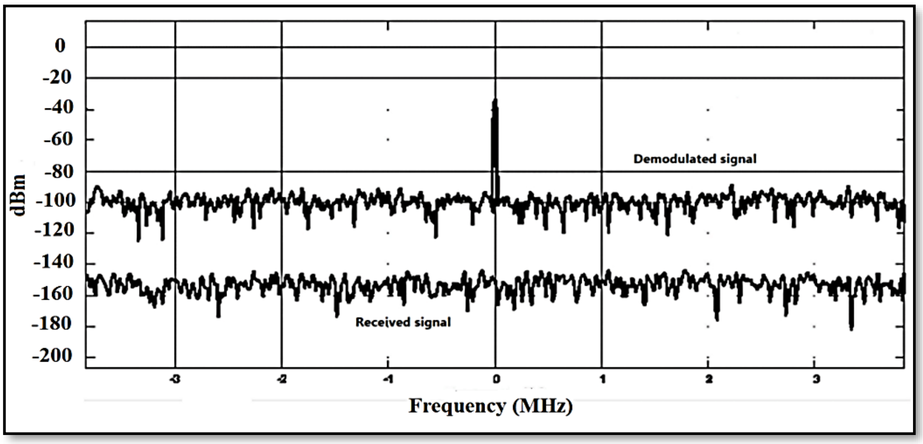



Figure 10. Received, demodulated, and removed DC offset signals with main loop detection

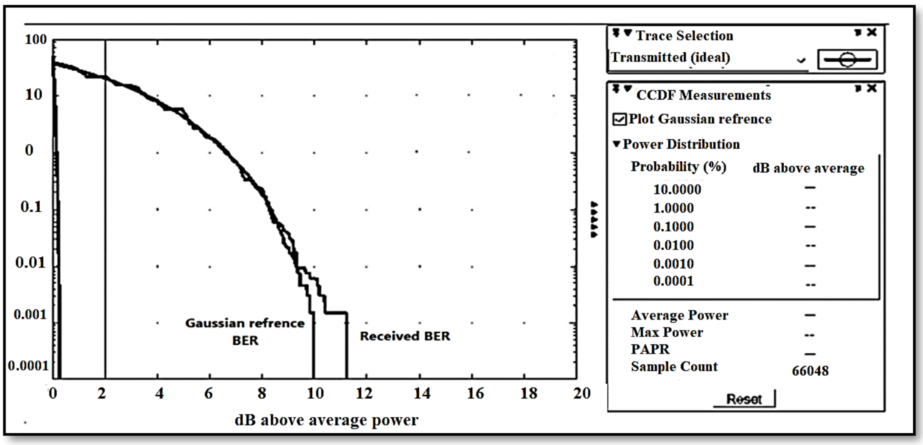



Figure 11. Received, demodulated, and removed DC offset signals with CCDF measurements

## 5. CONCLUSION

LTE-RF receiver design and simulated using MATLAB Simulink where where the design based on illustrating parameters of each stage in LTE RF receiver from generating LTE waveform to error vector magnitude EVM measurements. Simulation results with 8 MHz bandwidth the transmitted signal power -3200 dBm, the received signal power (-140 to -160) dBm, while the demodulated signal reaches to -60 dBm difference between main loop and side loop witch lead to high confident recovered signal. CCDF measurements applied on output signals that computes the power of complementary for cumulative distribution CCDF function from signal in time domain. Where CCDF curve shows the value of time that a signal stand still above the level of average power for the measured signal or the probability of signal power will be above the level of average power. From above for wireless broadband communication long-term evolution (LTE) is a standard for also mobile devices and data terminals, by using different radio interface together with core network improvements LTE increases the capacity and speed of mobile network as parameters illustrated in the proposed model.

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